06 Calculate PI using Random Numbers

In geometry the ratio of the circumference of a circle to its diameter is known as π. The value of π can be estimated from an infinite series of the form:

$\pi / 4 = 1 - (1/3) + (1/5) - (1/7) + (1/9) - (1/11) + ...$

There is another novel approach to calculate π. Imagine that you have a dart board that is 2 units square. It inscribes a circle of unit radius. The center of the circle coincides with the center of the square. Now imagine that you throw darts at that dart board randomly. Then the ratio of the number of darts that fall within the circle to the total number of darts thrown is the same as the ratio of the area of the circle to the area of the square dart board. The area of a circle with unit radius is just π square unit. The area of the dart board is 4 square units. The ratio of the area of the circle to the area of the square is π / 4.

To simuluate the throwing of darts we will use a random number generator. The Random module has several random number generating functions that can be used. For example, the function *uniform(a, b)* returns a floating point random number in the range a (inclusive) and b (exclusive).

Imagine that the square dart board has a coordinate system attached to it. The upper right corner has coordinates (1.0, 1.0) and the lower left corner has coordinates (-1.0, -1.0). It has sides that are 2 units long and its center (as well as the center of the inscribed circle) is at the origin.

A random point inside the dart board can be specified by its x and y coordinates. These values are generated using the random number generator. The way we achieve that is:

```
xPos = random.uniform (-1.0, 1.0)
yPos = random.uniform (-1.0, 1.0)
```

To determine if a point is inside the circle its distance from the center of the circle must be **strictly** less than the radius of the circle. The distance of a point with coordinates (xPos, yPos) from the center is *math.hypot (xPos, yPos)*. The radius of the circle is 1 unit.

The program that you will be writing will be called CalculatePI. It will have the following structure:

```
import math
import random

def computePI ( numThrows ):
  ...

def main ():
  ...

main()
```

Your function *main()* will call the function *computePI()* for a given number of throws. The function *computePI()* will simulate the throw of a dart by generating random numbers for the x and y coordinates. You will determine if that randomly generated point is inside the circle or not. You will do this as many times as specified by the number of throws. You will keep a count of the number of times a dart lands within the circle. That count divided by the total number of throws is the ratio π/4. The function *computePI()* will then return the computed value of PI.

In your function *main()* you want to experiment and see if the accuracy of PI increases with the number of throws on the dartboard. You will compare your result with the value given by math.pi. The quantity *Difference* in the output is your calculated value of PI minus math.pi. Use the following number of throws to run your experiment - 100, 1000, 10,000, 100,000, 1,000,000, and 10,000,000. You will call the function *computePI()* with these numbers as input parameters. Your output will be similar to the following, i.e. the actual values of your *Calculated PI* and *Difference* will be different but close to the ones shown:

```
Computation of PI using Random Numbers

num = 100        Calculated PI = 3.320000   Difference = +0.178407
num = 1000       Calculated PI = 3.080000   Difference = -0.061593
num = 10000      Calculated PI = 3.120400   Difference = -0.021193
num = 100000     Calculated PI = 3.144720   Difference = +0.003127
num = 1000000    Calculated PI = 3.142588   Difference = +0.000995
num = 10000000   Calculated PI = 3.141796   Difference = +0.000204

Difference = Calculated PI - math.pi
```

Your output ***must*** be in the above format. The number of throws must be left justified. The calculated value of π and the difference must be expressed correct to six places of decimal. There should be plus or minus sign on the difference. Read the relevant sections in the book on formatting.